Fundamental Performance Improvement of Microwave Kinetic Inductance Detectors for UVOIR Astrophysics

Completed Technology Project (2016 - 2019)

Project Introduction

Ultraviolet, Optical, and near-Infrared Microwave Kinetic Inductance Detectors (UVOIR MKIDs) are one of the most powerful new technologies to emerge out of the NASA APRA detectors program in the last decade. This proposal seeks to build on previous APRA grants to drastically improve the performance of UVOIR MKIDs. Like an X-ray microcalorimeter ultraviolet, optical, and near-IR (UVOIR) MKIDs are cryogenic detectors capable of detecting single photons and measuring their energy without filters or gratings. Our team has created this technology from the ground up, and fielded a 2024-pixel UVOIR MKID array on five separate observing runs at 5-m class telescopes. With 34 observing nights successfully completed and two astronomy papers published using MKID data (the first astronomy papers published using MKID data at any wavelength), UVOIR MKIDs are at TRL 5-6 for ground-based astronomy, and TRL 3 for space-based astronomy. The outstanding potential of these detectors was recognized in the recent NASA long term vision, "Enduring Quests, Daring Visions'', which recognized on page 88 that MKIDs have tremendous potential for future NASA UVOIR space missions, especially for finding Earth twins around nearby stars: "…microwave kinetic inductance detectors (MKIDs) would be a game-changing capability…''. Current UVOIR MKIDs feature array sizes in the 10-30 kpix range, energy resolution R=16 at 254 nm, ~70% pixel yield, and quantum efficiency that goes from 70% in the UV to 25% in the near-IR. These arrays, fabricated out of Titanium Nitride (TiN) on a high resistivity silicon substrate, are fully functional for ground-based science. However, our current MKIDs are far away from their theoretical limits, especially in yield (70% vs. 100%) and energy resolution (R=10 vs. R=100 at 400 nm). The yield is of especially urgent concern as missing pixels make accurate photometry difficult, especially for rapidly time variable sources like compact binaries that we have been studying. The yield is low because the reactively sputtered TiN that we make our MKIDs from is extremely sensitive to deposition conditions, and the resistivity and hence resonant frequency of the MKIDs varies dramatically across a wafer, as shown in. Our energy resolution is low because of a combination of factors related to the MKID material and the two level system (TLS) noise from our capacitors. In order to improve our current energy resolution, yield, and quantum efficiency we need to move in new directions. This proposal will focus on two main improvements: making better MKID resonator materials, and making lower noise capacitors.

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Organizational Responsibility

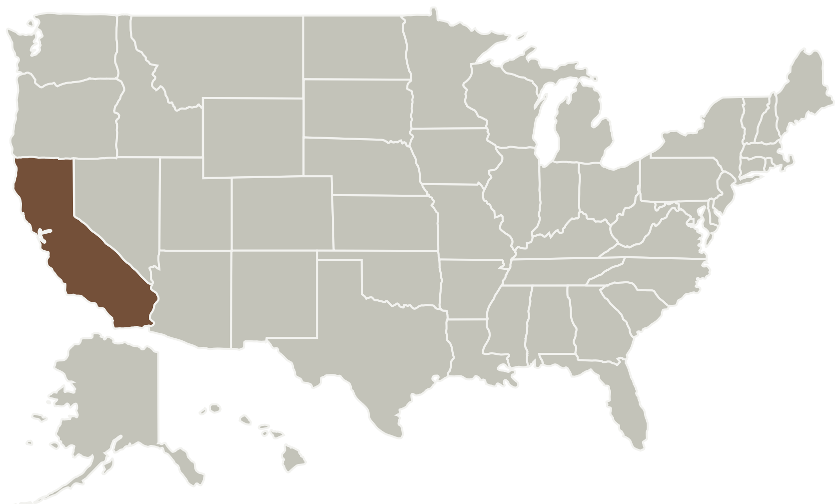
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of California-Santa Barbara(UCSB)	Supporting Organization	Academia Asian American Native American Pacific Islander (AANAPISI), Hispanic Serving Institutions (HSI)	Santa Barbara, California

Primary U.S. Work Locations
California

Project Management

Program Director:
Michael A Garcia

Program Manager:
Dominic J Benford

Principal Investigator:
Benjamin Mazin

Co-Investigators:
Bruce Bumble
Jessica A Sanchez

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.1 Detectors and Focal Planes

Target Destination
Outside the Solar System